A complementary approach for energy efficiency and comfort evaluation of renovated dwellings in Southern Europe

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Abstract

The European Directive on Energy Performance of Buildings, 2010/31/EU (EPBD recast), provided the framework on which all member states should improve their buildings’ ‘energy efficiency’. However, the application of this Directive should account for the specific climate conditions, economic and cultural background, and the real heating/cooling habits of each country. The Energy Certificate is a label that quantifies the nominal energy consumption needed to achieve predefined comfort conditions, comprising a methodology that is fundamental for countries where there is a permanent demand for heating during the winter. Nevertheless, in Southern European Countries, due to specific climate, economy (low incomes and expensive energy costs) and culture (behavior and habits), a permanent heating practice does not exist. Therefore, it is essential to characterize Southern European Buildings in a complementary way. This study proposes a methodology to quantify a “Passive Discomfort Index” by calculating the temperatures outside the comfort range, within the building, in realistic use conditions, that is, free-floating temperature or intermittent heating. This approach is especially important for retrofitting interventions on existing dwellings, where traditional energy improvement measures, mainly insulation measures, are often highly intrusive. The comfort assessment for Portuguese climate and a 19th century building was performed with an advanced numerical simulation tool, WUFI Plus, previously validated by experimental monitoring. Results suggest that insulation thickness has a very low impact on discomfort hours and energy consumption for intermittent heating scenarios. And, for free-floating scenarios, insulation measures may not have any significant impact at all. In addition, a logarithmic relationship seems to exist between heating scenarios and energy consumption/discomfort hours.

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1. Literature review

1.1. Portuguese buildings and thermal regulation framework

There are around 3.5 million buildings and 5.9 million dwellings for about 10.5 million inhabitants in Portugal [1]. Around 34% of these buildings need some type of intervention and half of those need intensive renovation to fulfill the current comfort and safety requirements. Thus, the weight of building refurbishment costs on the total spending of the Portuguese construction sector has increased this last decade to around 34% in 2014 [2], and even though this is still far from other European countries, it is significantly higher than in previous decades, when it was lower than 10%. Historic buildings constructed before 1960 make up 25% of the total number of buildings and, of these, around half were built using traditional systems, with stone masonry and wood floors and roof (without concrete) [1]. Most of these historic buildings have an additional architectural value, which is not always compatible with some of the traditional thermal improvement measures, such as insulation measures.

On the other hand, since the 2002/2010 Energy Performance of Buildings Directives [3] and its transposition for Portugal by National Regulation, with its first version in 2006 and its latest one in 2016 [4], an opportunity arose to enhance the thermal and energy performance of all buildings needing some type of retrofitting works, and for historic buildings in particular. The methodology for calculating energy needs and the minimal requirements imposed assume permanent heating/cooling habits, especially heating in winter, with the “heating degrees days” (HDD) parameter [3, 4] as a reference. However, these methodologies do not account for specific and realistic heating/cooling habits, namely the ones of southern European countries with Mediterranean/Atlantic climates.

1.2. Portuguese specific context regarding climate, income, energy prices and heating/cooling habits

The average temperature for the last 30 years was 17.4°C in Lisbon, 15.2°C in Porto [5] and 15.7°C for the entire country [6], significantly higher than the EU-27 average of 9.5°C [6]. In regards to the HDD parameter, Portugal has a 62% lower value than the EU-27 average of 3076 [7]. Portugal is also one of the poorest economies in EU, with a median disposable income (MDI) 39% lower than the EU-27 average [8], as shown in the Fig. 1 (a) ranking. In addition, energy prices (€ en) are some of the highest in the EU-27 (Fig. 1 (a)). Fig.1 (b) ranks a ‘Lack of Motivation to Heat’ index (LMH), calculated using formula (1), where data refers to Fig.1 (a) and € en is the simple average of gas and electricity prices. Portugal holds the top position in the ranking, along with other Mediterranean/Atlantic climates and poor economies.

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LMH = \frac{\text{€en} \times 10^6}{MDI + HDD}
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Fig. 1 - Median disposable income, electricity and gas prices in EU-28 (a) and ‘LMH’ index ranking in EU-28 (b)
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